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THE METHOD
Of Calculating the *Magnifying* POWER OF A *Reflecting* TELESCOPE,
ILLUSTRATED BY EXAMPLE.

WITH

A *General* TABLE of all the *Magnifying* POWERS of 12 ſuch TELESCOPES, from 4 to 100 Inches *focal* DISTANCE of the Great *Speculum*.

AS every one, who purchaſes a *Reflecting* TELESCOPE, is very inquiſitive about its *magnifying Power*, or *Powers*; and as this cannot be known but by Calculation from the given Dimenſions of the ſeveral Parts of the Inſtrument, I have thought it requiſite to lay the whole Proceſs before the Reader for his Satisfaction, if he underſtands it; and if he does not, I have ſhewn him what the magnifying Powers are in 12 different Lengths of Teleſcopes, in the following large Table, viz. from 4 to 100 Inches length in the Focal Diſtance of the great Metal.

The 3 firſt have only one magnifying Power, as they will not conveniently bear more. The 4th Teleſcope has 2 Eye-Pieces, and one ſmall Speculum, and has therefore two magnifying Powers. The 5th, 6th, 7th, 8th, and 9th, have each two Eye-Pieces and 2 ſmall Speculums, and conſequently 4 magnifying Powers. The 10th, 11th, and 12th, are ſo large, that they will admit of many Eye-Pieces and ſmall Speculums, and therefore may have a great Number of magnifying Powers; of theſe I have given the largeſt Power that each will bear, as near as I can judge.

In Plate II. Fig. 10. is the ANATOMY of a Reflecting Teleſcope, ſhewing the eſſential Parts of which it conſiſts, and which enter the Calculation; theſe are as follow:

The largeſt of the two Eye-glaſſes	HI
The focal Diſtance of Ditto -	IP
The ſmall Eye-Glaſs - -	US
The focal Diſtance of Ditto -	TP
The ſingle Lens equivalent to both,	MN
The focal Diſtance of Ditto -	$Pp = PW$
Diſtance between the two Eye-Glaſſes,	IT
The great Metal - -	*aa*
Center of the Hole - -	G
Diſtance of the Focus -	GF
Small Speculum - -	AD
Focal Diſtance -	Cf
Diſtance of the great Metal from the Eye-Glaſs - - -	GI.

Theſe Parts being known in any Teleſcope, the magnifying Power becomes known by the following Proceſs; the Line FW is known, from which take the Radius of the ſmall Metal C*g*; and call half the Remainder

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H, then H^2 is known. Again, multiply FW by focal Diſtance of the ſmall Metal Cf; and to the Product, add H^2; then from the Square Root of the Sum take H, and there will remain the Line = CF; this added to FW, gives the Line CW; and then the magnifying Power is thus expreſſed $\frac{GF}{CF} \times \frac{CW}{Pp}$, in Terms that are all known.

I ſhall illuſtrate this Rule for Calculation by the following Example.

		Inches.
Let the focal Diſtance of the large Metal be - -	$GF =$	12
Ditto of the ſmall Metal -	$Cf =$	1,5
Therefore its Radius is -	$Cg =$	3
The focal Diſtance of the great Lens	$IP =$	3
Ditto of the ſmall one -	$TP =$	1
Diſtance between them -	$IT =$	2
Focal Diſtance of the Equivalent Lens - -	$Pp =$	1,5
The Diſtance - -	$GI =$	0,7
Therefore the Diſtance -	$FW =$	20,2
Hence the Quantity	$FW - Cg =$	17,2
The half of which is -	$H =$	8,6
The Square of that is -	$H^2 =$	73,96
Add the Product of -	$FW \times Cf =$	30,3
The Sum is - -		104,26
The Square Root of which is -		10,211
From which take - -	$H =$	8,6
The Remainder is the Line	$CF =$	1,611
To which add -	$FW =$	20,2
The Sum is the Line -	$CW =$	21,811

Then the magnifying Power is

$$\frac{GF\times CW}{CF\times Pp}=\frac{18\times 21,811}{1,611\times 1,5}=162,5 \text{ Times.}$$

The Numbers in this Example are thoſe of the greateſt magnifying Power in a 2 Feet Reflector of the late Mr. *Short*'s make (viz. Teleſcope V. in the Table) but in the printed Paper of its magnifying Powers given with it, they are ſaid to be 55, 95, 130, and 200 Times; but theſe are very different from thoſe in this Table, eſpecially the *laſt*, which is only 162,5, inſtead of 200; by which it appears that Truth is attainable only by Calculation, with Certainty and Satisfaction.

In the Conſtruction of all theſe Teleſcopes, the two Eye-Glaſſes are ſo placed, that the Focus of each falls upon the ſame Point Q; which is the only genuine Poſition they can have; and the focal Diſtances of the ſmall Metals are ſuch as are found to be the moſt proper by Experience, and give a regular Proportion and Increaſe of magnifying Powers.

There is indeed a very ſtrong Deſire in many People to have a very great magnifying Power in their Teleſcopes and Microſcopes; this is not from Judgment, but from want of Uſe, and Experience, by which they ſoon learn the reaſon of the old Adage, *Ne quid nimis*, i. e. Covet not Extremes.

However, I have left room for a deeper Charge in moſt of the Teleſcopes, if it be required; thus for Example, the 3d Teleſcope might have an Eye-piece with Lenſes whoſe focal Diſtances are 1 and 2,5 Inches, and then the magnifying Power will be about 53,5; for it will be, as 2,5 : 3 :: 44,6 : 53,5 nearly. But with the Power 44,6 you ſee Jupiter's 4 Moons, and Saturn's Ring; and you can ſee no more with the Power 53,5; it therefore anſwers no Purpoſe but a bad one, viz. to render the Object more obſcure and indiſtinct.

The Truth of the above Rule for Calculation is, in every Part, demonſtrated in my New ELEMENTS of *Achromatic* OPTICS, Part V. Chap. IV. which is wholly upon the THEORY of *Reflecting* TELESCOPES, to which I refer the Reader who would be acquainted with the *Rationale* of Optical Inſtruments, and has no Averſion to a *Turnpike-Road* to Knowledge.

I have hitherto conſidered the magnifying Power of Teleſcopes in general, and in regard to diſtant Objects only; but the curious Reader ought to be informed, that Teleſcopes may be ſo conſtructed as to magnify Objects *very near us* in a much higher Degree, even ſo far as to be not only a MEGALASCOPE in the moſt perfect Degree, but alſo a MICROSCOPE too, in a great Meaſure; as will appear by the following Example.

Suppoſe an Object placed 36 Inches from the great Speculum of Teleſcope III. the focal Diſtance GF will in ſuch a Caſe be increaſed to 12 Inches, and the magnifying Power to 75$\frac{1}{2}$ Times, which is ſufficiently great to make it a MEGALASCOPE.

But for theſe Purpoſes a deeper Charge may be given, for P*p* may be only 1$\frac{1}{4}$, and alſo C*f* the ſame, inſtead of 1$\frac{1}{2}$ Inch; and then the magnifying Power will be no leſs than 104 Times for an Object at the Diſtance of 3 Feet; which

which therefore will appear 23 Times larger than when viewed at 8 Inches Diſtance, the neareſt Limit for *diſtinct Viſion* to the naked Eye; and therefore may very truly demonſtrate the Inſtrument a MICROSCOPE in this Caſe.

In ſhort, the *Reflecting Teleſcope* is an univerſal Inſtrument for magnifying Objects in every Situation, and in every reſpect whatſoever; nor will this appear at all ſtrange to any one who conſiders that a *Reflecting* TELESCOPE has in itſelf a *double Power of magnifying*, viz. That of a common TELESCOPE, and that of a *compound* MICROSCOPE, combined together. It is alſo capable of an Apparatus to make it a *Catoptric* MICROSCOPE, and a *Solar* MICROSCOPE, in a literal Senſe, viz. by magnifying Objects upon the *real Face of the Sun*, in a moſt delightful Manner, as is ſhewn more at large in a former Eſſay; the Uſe, therefore, that is generally made of this noble Inſtrument is *only one out of many*, and is but a *ſmall Part the whole.*

N. B In all theſe Teleſcopes there might be added an Eye-Piece to magnify leſs than the firſt of each Teleſcope in the Table, which would not only encreaſe the Number and Variety of magnifying Powers, both as a *Teleſcope*, *Megalaſcope*, and *Microſcope*, but would be found very uſeful on many other Occaſions. Thus for Inſtance, ſuppoſe in the 5th Teleſcope a third Eye-Piece were added, with Glaſſes 5, and 2 Inches focal Diſtance; then the magnifying Power would be leſſened in Proportion of $2\frac{1}{2}$ to 2, or of $63\frac{1}{2}$ to 51, and of 125 to 100; there would then be ſix magnifying Powers, viz. 51, $63\frac{1}{2}$, $85\frac{1}{2}$, 100, 125, 163.

A TABLE

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A
TABLE
OF THE
DIMENSIONS and *Magnifying* POWERS
OF
12 Reflecting TELESCOPES.

Teleſ.	IP	TP	TI	GI	PW	GF	Cf	CF	CW	Mag. Power.
I.	2	0,75	1,25	0,5	1	4	1	1,176	6,68	23,6
II.	2,5	1	1,5	0,5	1,25	6	1,25	1,44	9,44	31,5
III.	3	1	2	0,5	1,5	9	1,5	1,71	12,7	44,6
IV.	4	1,5	2,5	0,5	2	12	1,5	1,65	16,15	58,6
	3	1	2	0,5	1,5	12	1,5	1,66	15,66	75,5
V.	4	1,5	2,5	0,75	2	18	3	3.42	24,2	63,5
	3	1	2	0,75	1,5	18	3	3.31	23,6	85,4
	4	1,5	2,5	0,75	2	18	1,5	1,61	22,4	125,2
	3	1	2	0,75	1,5	18	1,5	1,61	21,9	162,9
VI.	4	1,5	2,5	1	2	24	4	4.65	31,6	81,7
	3	1	2	1	1,5	24	4	4.59	31,1	108,4
	4	1,5	2,5	1	2	24	2	2,14	29,1	163,1
	3	1	2	1	1,5	24	2	2,15	28,6	213,2
VII.	4,5	1,75	2.75	1,5	2,25	30	4,5	5.09	38,8	101,7
	3,5	1,25	2,25	1,5	1,75	30	4,5	5.09	38,3	129
	4,5	1,75	2,75	1,5	2,25	30	2,25	2,4	36,2	200,8
	3,5	1,25	2,25	1,5	1,75	30	2,25	2,4	35,6	254,5
VIII.	5	2	3	1,5	2,5	36	4,5	5	45	130
	3,5	1,25	2.75	1,5	1,75	36	4.5	5	44.25	182
	5	2	3	1,5	2,5	36	2,5	2,65	42,6	231,7
	3,5	1,25	2,75	1,5	1,75	36	2,5	2,66	41,9	339
IX.	6	2	4	1,5	3	42	4,5	5,08	51,6	142
	4	1,5	2,5	1,5	2	42	4,5	4,94	50,44	214,4
	6	2	4	1,5	3	42	2,3	2,63	49,1	261,5
	4	1,5	2,5	1,5	2	42	2,5	2,64	48,1	383
X.	4	1,5	2,5	2	2	50	3	3,16	57.6	456
XI.	5	2	3	2	2,5	60	3	3,14	67,6	517
XII.	6	2,5	3,5	3	3	100	4	4.15	110	884.5

To fill up a vacant Page, it may not be diſagreeable to thoſe who are curious in Optics, and particularly delighted with the moſt rational Amuſements of the Solar Microscope, to be informed, that the fineſt Effects of that Inſtrument cannot be produced but by a Conſtruction of *three Convex Lenſes*, which will make a Circle of Light 20 Feet Diameter (if the Room will admit of it) at the Diſtance of 20 Feet from the Glaſs; and ſo in Proportion for any other Diſtance or Width of the Room; therefore in a Room only 10 or 12 Feet high, the whole Side of the Room will be nearly enlightened with the Semicircle only, and filled with the amazing Views of magnified Objects in the Sliders belonging to the Microſcope and Megalaſcope Part. Nor will Light be wanting in ſo large a Circle, if the exterior Lens be $1\frac{3}{4}$ Inch broad; but I have conſtructed one for my own Uſe, wherein that Lens is $4\frac{1}{2}$ Inches and the Light is thereby increaſed near 10 Times above what is produced by a Glaſs of $1\frac{1}{2}$ Diameter in common Uſe. This makes the Inſtrument large, it is true; but being fixed, it is as eaſy and free in its Motions, and gives no more Trouble in its Uſe, than one of the uſual Size. Not only ſo, but it would be very feaſible to have the *Illuminator* 6 Inches in Diameter, and a Reflecting Speculum of the ſame Width, and 18 Inches long; which would ſerve for 7 or 8 Months in the Year without any Deficiency of Light, which is now 16 Times greater than in the common Solar Microſcope. How highly then, muſt the *Microſcopic* Views of all the wonderful *Minutiæ* of Nature, when placed in ſuch a tranſcendant Degree of Light, gratify the Eye, and tranſport the Mind of every curious and rational Beholder!

THE END.

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